Ultra-Fast Measurements With the Pinhole Ion Velocity Imager

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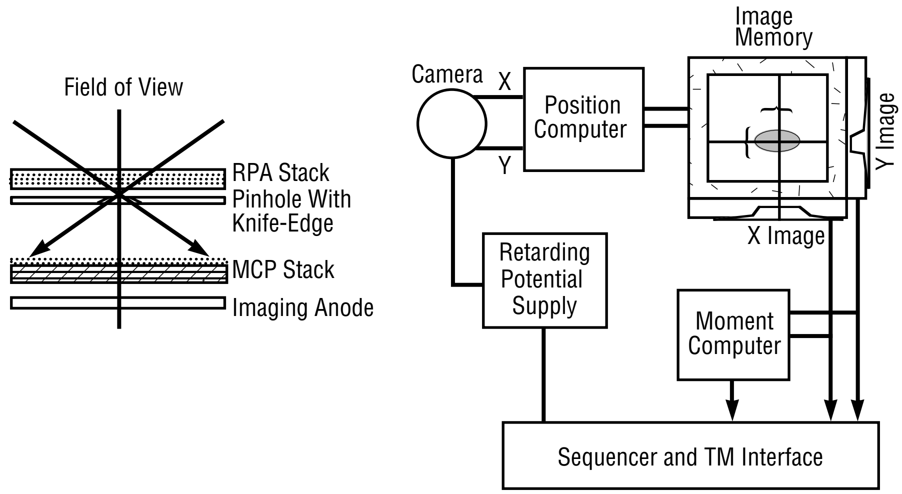
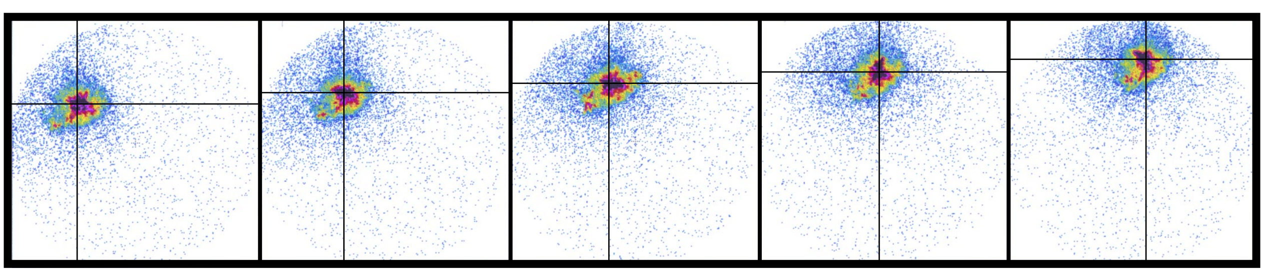


FIGURE 174.—A cross-section drawing of the pinhole camera with its functional schematic. The UV diffraction grating filter is not shown.

Results from recent sounding rocket experiments have led to an increased emphasis on resolving smaller scale ionospheric plasma structures than can be achieved with present methods. For these previous rocket flights, three-diminsional ion velocity distribution measurements were provided by the Scanning Thermal Ion Composition Spectrometer (STICS)[1,2] by varying voltages to measure the particle energy, its incident angle in one direction, and its mass. The spinning of the rocket was used to measure the second angle and therefore obtain the third dimension in velocity. A new charged particle imaging detector called the pinhole ion velocity imager (PIVI) is in development to permit ultra-fast two-dimensional image sampling of the plasma in order to resolve narrow spatial features and fluctuations while traveling at high velocities. The two-dimensional images are reduced on board to parameters used to calculate and describe the macroscopic properties of the plasma given by the density, temperature, and flow velocity components. Faster methods of measuring these characteristics of the plasma at the lowest possible energies are the only way to attain a clearer understanding of the mechanisms involved in particle transport and heating of the ionosphere.

The essential part of the PIVI design is a pinhole aperture used to view the rammed plasma. This pinhole mounts on top of microchannel plates which are thin plates of a million tiny glass channels used to amplify the incident charged particle for detection. Below the MCP stack, an anode with four charge-sensitive outputs resolves the position of the incident particle into two dimensions so that each particle event is separated into X and Y coordinate positions. Other components of the PIVI design are a diffraction grating filter and a retarding



	1	2	3	4	5
Total # of Cnts.	1.23E4	1.0E4	0.98E4	0.94E4	0.90E4
Average X:	68.46	85.66	100.71	121.05	137.47
Average Y:	167.03	175.43	184.86	196.19	208.46
Std. Deviation X:	14.94	19.92	24.90	21.91	17.93
Std. Deviation Y:	20.92	24.90	22.91	18.93	21.91

FIGURE 175.—Five pinhole images from initial testing of PIVI and the computed averages and standard deviations after collapses in both the X and Y dimensions.

potential analyzer (RPA). The filter is on top of the pinhole to suppress unwanted ultraviolet while maintaining sensitivity to the charged particles. Below this diffraction grating is the RPA that selects the incident particle's energy/charge and is managed by a feedback system that varies the energy voltage as it monitors the count rate. Figure 174 shows the cross-section drawing of the pinhole imager and a functional schematic.

During each accumulation, histograms are developed in memory of the number of particle events versus their incident X and the Y position value. In parallel with this time period, the total number of counts, the average, and the standard deviation of the X and Y histograms from the previous accumulation is computed and the memory is reset. Figure 175 shows an example of five pinhole images obtained during initial testing of the PIVI. The pinhole aperture was rotated below the particle source in 5-degree increments and a 60-sec accumulation was taken at each step. A crosshair is placed at the centroid of the image. The table lists the total number of counts, the average and the standard deviation in pixel units for each image dimension. The characteristics of the plasma given by the density, temperature, and flow velocity components are determined with these reduced parameters, the knowledge of the pinhole camera dimensions, the particle energy, and the spacecraft velocity.

PIVI will also provide a significant improvement in our present capability to diagnose the ion source in the low-energy electron and ion facility (LEEIF). This particle source is used for the testing and calibration of instruments before their flight and therefore it is very important to be able to routinely measure the characteristics of the ion source while testing. This pinhole camera design will yield rapid diagnosis of not only the spatial distribution but also the angular distribution of the ion source, which has never been obtained before.

[1]Coffey V.N.; Moore T.E.; Pollock C.J.: The Scanning Thermal Ion Composition Spectrometer. AGU Monograph on Measurement Techniques for Space Plasmas, submitted, 1996.

[2]Moore T.E.; Chandler M.O.; Pollock C.J.; Reasoner D.L.: Plasma Heating and Flow in an Auroral Arc. *Journal of Geophysical Research*, vol. 101, pp. 5279–5297l, 1996

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Biographical Sketch: Victoria N. Coffey joined NASA/MSFC in 1984 and supports the flight instrument programs in the Space Physics Branch. She has optimized particle throughput designs, tested and calibrated the instruments before flight, and analyzed flight data to study ionospheric transport processes. She is currently completing her master's degree in physics at UAH.